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Railbus Development and Demonstration Program

Summary Report

Prepared for
Transport Canada
Passenger Policy and Programs

by
Transportation Development Centre

JUNE 1987

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by

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Un sommaire en français de ce rapport est inclus avant la Table des matières.

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Team Engineering Associates	Winnipeg, Manitoba
Greater Winnipeg Water District Railway	Winnipeg, Manitoba
CN Rail	Winnipeg, Manitoba Montreal, Quebec
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Canadian Institute of Guided Ground Transport	Kingston, Ontario
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17. Abstract

This summary technical report describes the main activities and results of the Railbus Development and Demonstration Program undertaken by Transport Canada over the period April 1984 to December 1986.

The program was intended to assess whether the railbus concept could offer an attractive and lower cost means of providing rail service in sparsely populated, remote communities as an alternative to existing, conventional, locomotive-hauled coaches. Railbus technology incorporates a road coach body, engine, and transmission into a simplified, two axle rail vehicle. Mass-produced components of road vehicles are substituted for the traditionally high-cost, custom-made, rail vehicle subsystems.

A summary description is presented of each of the four program elements undertaken, WCSS railbus, BRE-Leyland 141 railbus, UTDC/MCI railbus, economics and routing study, including results, conclusions, and recommendations drawn from contractors' reports. Overall conclusions and recommendations are also given.

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17. Résumé

Ce rapport présente les grandes lignes et les résultats du Programme de mise au point et de démonstration du railbus, entrepris par Transports Canada d'avril 1984 à décembre 1986.

Ce programme avait pour but de vérifier si le railbus pouvait constituer un moyen attractif et moins coûteux d'assurer la desserte des régions isolées à faible densité de population, comparativement aux trains classiques. Le railbus est un autocar routier classique adapté à la circulation sur rails par l'adjonction de deux essieux. Il se caractérise par des organes et accessoires de type routier produits en grande série, donc moins coûteux que les sous-systèmes conçus exprès pour les matériels ferroviaires.

Dans ce rapport sont résumés les travaux concernant les quatre grands éléments du programme : le railbus WCSS, le railbus BRE-Leyland 141, le concept UTDC/MCI et, enfin, l'étude technico-économique des relations à desservir. Chaque chapitre correspondant est complété par les résultats, conclusions et recommandations formulés par les contractants dans leurs comptes rendus. Les conclusions et recommandations de l'équipe d'étude du CDT sont également reprises.

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Among the many organizations which contributed to the work, the author offers a special thanks to the following: Transportation Technology Ltd., Winnipeg Coach Sales and Service Ltd., CN Rail, CANAC Consultants Ltd., VIA Rail, Greater Winnipeg Water District Railway, Canadian Institute of Guided Ground Transport, National Research Council, Canadian Transport Commission, Northern Manitoba Regional Development Corporation, municipal governments of Thompson, Thicket Portage, and Pikwitonei.

Particularly recognized is Mr. M.J. Babulic of Inco Ltd. who energetically and effectively voiced the needs of local communities in the Thompson area for improved rail transportation services. With Inco's approval, he gave of his own time and made available his company's facilities in support of various project requirements.

EXECUTIVE SUMMARY

This report presents the main activities and results of the Railbus Development and Demonstration Program undertaken by Transport Canada (TC) under an intra-departmental tasking agreement signed in May 1985 between Passenger Policy and Programs Branch, Ottawa, and the Transportation Development Centre (TDC), Montreal.

The program was intended to assess whether the railbus concept could offer an attractive and lower cost means of providing rail service in sparsely populated, remote communities as an alternative to existing, conventional, locomotive-hauled coaches. Railbus technology incorporates a road coach body, engine, and transmission into a simplified, two-axle rail vehicle. Mass-produced components of road vehicles are substituted for the traditionally high-cost, custom-made, rail vehicle subsystems.

The scope of the program was limited to remote services, but was otherwise wide ranging and encompassed an examination of railbus technology, operating rules, institutional arrangements, types of service offered, and economic considerations. Passenger demonstration operation was to be undertaken with domestically developed and offshore railbus technologies. It was hoped that this would lead to a new formula for remote rail services that would be more cost-effective than traditional methods.

During the course of the program, the introduction of new passenger rail legislation and VIA's growing interest in railbus technology for regional and corridor feeder as well as remote services curtailed the need for a wide ranging, multi-dimensional evaluation relating only to remote services. Thus, in July 1986 Transport Canada decided to terminate its work under the intra-departmental agreement and mandated VIA Rail to pursue further railbus initiatives. Development of a new Canadian railbus was put on hold at the completion of Phase 1 of the work. The detailed routings and economics study to be performed by TC was cancelled.

SOMMAIRE

Ce rapport présente les grandes lignes et les résultats du Programme de mise au point et de démonstration du railbus, lancé par Transports Canada aux termes d'un accord intraministériel conclu, en mai 1985, entre Politiques et Programmes — Voyageurs à Ottawa et le Centre de développement des transports (CDT), à Montréal.

Ce programme avait pour but de vérifier si le railbus pouvait constituer un moyen attractif et moins coûteux d'assurer la desserte des régions éloignées à faible densité de population, comparativement aux trains classiques. Le railbus est un autocar routier classique adapté à la circulation sur rails par l'adjonction de deux essieux. Il se caractérise par des organes et accessoires de type routier produits en grande série, donc moins coûteux que les sous-systèmes conçus exprès pour les matériels ferroviaires.

Même si le programme se limitait au contexte de la desserte des régions éloignées, il n'en demeure pas moins que l'examen de la question a été très fouillé : tour d'horizon de la technologie du railbus, règles d'exploitation, dispositions administratives, types de services offerts et faisabilité économique. Le programme de démonstration devait utiliser des matériels réalisés tant au Canada qu'à l'étranger, dans l'espoir qu'il déboucherait sur une nouvelle formule de desserte des régions isolées qui serait plus économique que l'ancienne.

Pendant que se déroulait le programme, une nouvelle loi sur le transport ferroviaire voyageurs a été déposée et VIA Rail a voulu étudier la possibilité d'utiliser le railbus comme moyen de rabattement sur les transports régionaux ou de corridor, en plus de la desserte des régions isolées. Ces événements ont rendu inutile la poursuite du programme d'évaluation initial qui n'envisageait que la desserte des régions isolées. C'est ainsi qu'en juillet 1986, Transports Canada, mettant un terme à l'accord intraministériel, a confié à VIA Rail le mandat de poursuivre les actions concernant le railbus. De plus, le développement d'un railbus de technologie canadienne a été suspendu à l'issue de la phase I des travaux, tandis que l'étude technico-économique détaillée des relations à desservir, que Transports Canada devait prendre en charge, a été annulée.

The work actually undertaken by Transport Canada involved many technical and operational initiatives with various contractors. Results have been documented in numerous reports, many of which have been published as TC publications (see Chapter 8, References). It was felt, however, that there was a need to combine these in one document for easy reference and to highlight the main results. It was also considered that it would be useful to present observations, conclusions, and recommendations by the TDC project team.

This report provides a summary of each of the four program elements undertaken: WCSS railbus, BRE–Leyland 141 railbus, UTDC/MCI railbus, economics and routings study. Each of these chapters presents results, conclusions, and recommendations drawn from contractors' reports. A separate chapter presents some overall conclusions and recommendations offered by the TDC project team.

WCSS Railbus

An experimental prototype railbus vehicle was manufactured by Winnipeg Coach Sales and Service Ltd. (WCSS). It was based on a simple conversion of a used Flyer highway coach to rail operation, which involved installing modified railway wheels, stabilizing the front axle, strengthening the front suspension to minimize sway, and installing a hydraulically operated turntable for reversing direction.

After this initial conversion, Transportation Technology Ltd. (TTL) made further modifications to satisfy CN and CTC requirements and to improve performance and reliability. The vehicle was tested without passengers on the Inco Pipe Mine Railway and on the CN Thompson–Pikwitonei–Thicket Portage line in late April and early May 1986.

Two weeks of a planned eight-week, free-fare, passenger demonstration operation were completed on the same CN line in late June and August 1986. The passenger demonstration had to be terminated prematurely owing to a structural failure of the modified rail wheel.

A total of 8300 km of operation was accumulated during the course of the work. In general,

Le travail accompli entre–temps par Transports Canada par l'entremise de divers contractants a concerné un grand nombre d'aspects techniques et opérationnels. Même si de nombreux comptes rendus ont été publiés par ce ministère (la liste en est donnée au chapitre 8 — Références bibliographiques), le besoin s'est fait sentir de compiler un ouvrage qui les engloberait tous, d'abord pour en faciliter la consultation et ensuite pour mettre en évidence les principales réalisations. Enfin, il a été jugé utile de le compléter par les observations, conclusions et recommandations formulées par l'équipe d'étude mise sur pied par le CDT.

Ce rapport résume donc les travaux concernant les quatre grands éléments du programme : le railbus WCSS, le railbus BRE–Leyland 141, le concept UTDC/MCI et, enfin, l'étude technico–économique des relations à desservir. Chacun des chapitres correspondants donne les résultats, conclusions et recommandations tirés du compte rendu du contractant respectif, tandis que le dernier chapitre présente les conclusions générales et les recommandations formulées par l'équipe d'étude du CDT.

Railbus WCSS

La Winnipeg Coach Sales and Service Ltd. (WCSS) a réalisé un prototype expérimental de railbus en adaptant un autocar Flyer à la circulation ferroviaire par la pose de roues métalliques modifiées, la stabilisation du train avant, le renforcement de la suspension avant de manière à réduire les mouvements de roulis et la mise en place d'une table tournante hydraulique pour inverser la marche.

Plus tard, Transportation Technology Ltd. (TTL) a apporté d'autres modifications afin de répondre aux exigences du CN et de la Commission canadienne des transports (CCT) et de relever les performances et la fiabilité. Fin avril, début mai 1986, ce véhicule a été soumis à des essais de service sans passagers sur le tronçon de voie appartenant à l'Inco Pipe Mine et sur la ligne du CN faisant la liaison Thompson–Pikwitonei–Thicket Portage.

À la fin de juin et en août 1986, un programme de démonstration a été lancé sur la ligne du CN susmentionnée, avec des passagers non payants. Prévu pour huit semaines, ce programme n'en a duré que deux, le service ayant dû être arrêté suite à la rupture d'une des roues métalliques modifiées.

Au total, 8 300 km ont été parcourus. Les modifications visant à adapter le matériel à la circulation ferro-

the rail related modifications performed satisfactorily in terms of stability, curving, switching, braking, and traction. The vehicle was, however, unreliable as a result of its age and considerable mileage accumulated as a highway coach. In technical tests, the vehicle proved to be capable of sustained safe speeds of up to 90 km/h. Ride was judged to be "just satisfactory" on the British Rail Ridemeter scale. Interior noise, at 87 db(A), was a problem and was mainly due to the location of the engine and the low noise insulation provided. The failure of the modified rail wheel (which incorporates a road wheel hub) demonstrated the relative harshness of the railway environment on vehicle wheels, suspension, and undercarriage components. It was shown that suspensions designed for road vehicles are not suitable in a rail environment. Rerailing, winch and turntable operation required a minimum of two persons for safety.

BREL 141 Railbus

TDC and British Rail Engineering Ltd.(BREL) signed a letter of understanding on January 23, 1986, to bring the BREL 141 demonstrator railbus to Canada. The BREL vehicle was shipped from England on January 25 and arrived at VIA's Montreal maintenance facilities from Halifax on February 8, 1986.

Under contract to TDC, VIA undertook a number of modifications to satisfy CN operational and CTC regulatory requirements, performed vehicle acceptance tests, and served as the vehicle operator. Under an inter-departmental agreement with TDC, the National Research Council (NRC) performed the vehicle engineering tests.

Acceptance tests were conducted to qualify the vehicle for operation on CN lines. These included coupling to a CN locomotive, evaluation of curving and switching behaviour on yard tracks, braking operation checks, inspection of safety appliances, operation of all mechanical and electrical systems, measurement of wheel profiles, examination of pilot and general construction for potential derailment hazards.

The NRC tests addressed engineering performance parameters such as wheel lift, vibration, curving

viaire ont généralement donné de bons résultats sur les plans de la stabilité, de l'inscription dans les courbes, du passage sur les aiguillages, du freinage et de la qualité de l'adhérence. Par contre, la fiabilité générale a été faible, attribuable à l'âge du véhicule et à son usure alors qu'il circulait sur les routes. Sur le plan technique, le véhicule s'est montré capable de soutenir, en toute sécurité, des vitesses allant jusqu'à 90 km/h. Sur le plan confort de roulement, il n'a pas obtenu plus que "juste satisfaisant", suivant l'échelle de confort établie par la British Rail. Le niveau sonore intérieur, à 87 dB(A), a été jugé trop élevé; il était attribuable à l'emplacement du moteur et à l'isolation acoustique insuffisante. La rupture de la roue (calée sur un moyeu type routier) a mis en évidence la rigueur de la circulation ferroviaire et ses effets sur les roues, la suspension et le châssis. Il a été établi qu'une suspension routière ne convient pas à la circulation sur rails et aussi que, pour des raisons de sécurité, il ne faut pas moins de deux personnes pour effectuer les manoeuvres de remise sur rails et actionner le treuil et la table tournante.

Railbus BRE-Leyland 141

Le CDT et la British Rail Engineering Ltd. (BREL) ont signé, le 23 janvier 1986, une entente portant sur l'importation au Canada d'un railbus modèle 141 aux fins d'essais. Expédié d'Angleterre le 25 janvier, le véhicule est arrivé aux ateliers d'entretien de VIA Rail à Montréal, via Halifax, le 8 février 1986

Aux termes d'un marché avec le CDT, VIA Rail a entrepris de modifier le véhicule pour le rendre conforme aux exigences opérationnelles et réglementaires du CN et de la CCT. Elle a procédé aux essais d'acceptation, à titre d'exploitant attitré. Suite à une entente interministérielle avec le CDT, le Conseil national de recherches (CNR) a entrepris les essais du véhicule sur le plan technique.

Les essais d'acceptation ont été faits afin de vérifier son aptitude à circuler sur les voies du CN. Parmi ces essais, il y a eu l'essai d'attelage à une locomotive du CN, des essais d'inscription en courbe, de manoeuvre en gare et de freinage, sans oublier l'essai des dispositifs de sécurité et des systèmes électriques et mécaniques, le mesurage du profil des roues et l'évaluation de la robustesse générale et celle du chasse-corps en particulier, dans l'optique de la prévention des risques de déraillement.

Pour sa part, le CNR s'est penché sur les aspects techniques tels que délestage des essieux, vibrations,

performance, tracking stability, acceleration, braking, as well as passenger comfort criteria such as ride quality, lighting, temperature, and noise.

A free-fare passenger demonstration operation was undertaken on the CN line between Thompson, Pikwitonei, and Thicket Portage for an eight-week period during July 1 to August 23, 1986.

A total of 9,500 km of operation was accumulated during the course of the work. The vehicle performed well in operational tests. Equipped with new wheels, it demonstrated stable ride characteristics up to the maximum speed tested of 100 km/h(62 mph). Acceptable curving performance was observed over the 29–64 km/h (18–40 mph) speed range tested, as shown by the wheel lateral–to–vertical (L/V) force ratio measurements. Ride comfort proved to be adequate for short– and medium–length journeys as shown by the ISO Standard for reduced comfort values. Low acceleration figures reflect the low vehicle power–to–weight ratio. The signals shunting capability was found to be approximately equivalent to that of an RDC. Hot box detector reading of wheel bearing temperature was not possible owing to inappropriate scanner and readout systems for the two–axle railbus. The passenger demonstration showed that the vehicle can provide an attractive service. The vehicle entry steps were the most significant area of negative public comment owing to their design for passenger entry from high level platforms commonly found in Britain. The operating crews liked the vehicle and found it easy to operate. The vehicle operated reliably during the test and demonstration periods. The only significant equipment problem encountered was the failure of an electrical alternator.

UTDC/MCI Railbus

A contract was signed with Transportation Technology Ltd. on January 2, 1985, for the design, manufacture, and demonstration of a Canadian advanced–design railbus. The vehicle was to be based on an MCI 102A2 intercity highway coach placed on rail wheelsets and suspension. The work was to be divided into four phases: 1) preliminary design and specification, 2) detailed design and construction, 3) testing at the Kingston track, 4) testing on a private rail line. As mentioned earlier, only Phase I of this work was completed.

performances dans les courbes, stabilité du bogie, accélérations, freinage et, du point de vue des passagers, douceur de roulement, éclairage, climatisation et insonorisation.

Du 1er juillet au 23 août 1986, une liaison expérimentale a été réalisée entre Thompson, Pikwitonei et Thicket Portage, ne transportant que des passagers non payants.

Une distance de 9 500 km a été couverte durant ces huit semaines, le véhicule se comportant de manière satisfaisante. Équipé de roues neuves, il s'est montré stable jusqu'à la vitesse maximale essayée de 100 km/h (62 mi/h). L'inscription en courbe a été jugée acceptable dans l'intervalle des vitesses essayées : 29 à 64 km/h (18 à 40 mi/h), si on considère le paramètre du rapport des forces transversales aux forces verticales (L/V). Sur le plan douceur de roulement, le véhicule s'en est bien tiré lorsque les parcours étaient courts ou moyens, à en juger par les essais inspirés de la norme ISO concernant la limite au confort réduit. Les faibles accélérations observées sont la conséquence d'un rapport puissance–poids plutôt bas. Pour ce qui est de l'aptitude au shuntage des signaux, elle s'est avérée égale à celle d'un autorail diesel. Il n'a pas été possible d'obtenir des lectures du détecteur des boîtes en surchauffe étant donné l'incompatibilité du système de détection et d'interprétation en place avec la configuration deux essieux du railbus. Les passagers ont apprécié le véhicule, sauf l'emmarchement qu'ils considéraient comme trop élevé, celui–ci ayant été conçu en fonction des quais surélevés très répandus en Grande–Bretagne. Les conducteurs l'ont trouvé agréable et aisé à conduire. Sa fiabilité a été bonne tout le temps des essais et de la démonstration. Le seul défaut important constaté a été la panne d'un alternateur.

Railbus UDTC/MCI

Le 2 janvier 1985, le Centre de développement des transports a conclu avec Transportation Technology Ltd. un marché portant sur l'étude, la réalisation et la démonstration d'un railbus canadien de type avancé, formé de la carrosserie d'un autocar MCI 102A2 adaptée à la circulation sur rails. Le programme devait comporter quatre phases : 1) étude préliminaire et spécifications, 2) étude détaillée et réalisation, 3) essais sur la voie à Kingston et 4) essais sur une voie ferrée privée. Seule la phase I a été achevée.

Design performance of the vehicle was analyzed with respect to specified performance targets. Engineering concepts for the modification hardware to the base bus were developed regarding: rail suspension including rail wheels and axles; driveline and propulsion; brakes; special equipment such as snow-plow, lights, horns, etc.; means of obtaining bi-directional operation. The work resulted in the preparation of a conceptual design, technical specifications, and some preliminary design engineering.

Les caractéristiques ont été définies en fonction des performances attendues, les ingénieurs étudiant les divers composants nécessaires à la réalisation du véhicule modifié : suspension ferroviaire complète avec essieux et roues; système propulsif et chaîne cinématique; freins; équipements particuliers, tels que chasse-neige, feux de signalisation, avertisseurs, etc.; réversibilité de la marche. Plusieurs étapes ont ainsi été réalisées, soit l'étude conceptuelle, les spécifications et une partie de l'avant-projet.

The studies identified no technical problems that would render infeasible the conversion to rail. A suspension design with cross-bracing between the single-axle subframes was estimated to achieve a ride comparable to conventional rail coaches at targeted speeds of up to 100 km/h. The 229 kW (305 hp) Detroit Diesel Allison 6V92-TA engine combined with a four-speed automatic transmission with lock-up in the top three gears could achieve the required maximum speed of 100 km/h and climb a 3% grade at 80 km/h at full accessory load.

L'étude a montré la faisabilité technique de la conversion envisagée. Une suspension du type à liaison croisée des essieux simples offrira un confort équivalant à celui d'un matériel classique jusqu'à la vitesse maximale prévue de 100 km/h. Un moteur Detroit Diesel Allison modèle 6V92-TA fournissant 229 kW (305 HP) et relié à une transmission automatique quatre rapports avec verrouillage du convertisseur aux trois derniers rapports entraînera le véhicule à la vitesse maximale de 100 km/h et lui permettra de franchir des rampes de 3 p. 100, à 80 km/h, à pleine charge.

Although technically feasible, neither track-based nor vehicle-mounted systems for turning the vehicle were found to be operationally desirable. Bi-directional operation could be achieved through the use of a second driver's position at the rear on the pre-production prototype vehicle and a back-to-back married pair for production vehicles where additional capacity was required.

Bien que techniquement réalisables, ni la table tournante sur voie ni une intégrée au véhicule n'ont été jugées souhaitables du point de vue exploitation. La solution à privilégier serait de prévoir un deuxième poste de conduite sur le prototype présérie et une configuration de rame réversible pour les véhicules de série mis en service en vue de répondre à une demande plus forte.

Economics and Routings Study

Étude technico-économique des relations à desservir

As a preliminary step to undertaking a detailed economics and routings study, the Canadian Institute of Guided Ground Transport (CIGGT) was commissioned in July 1985 to assess the Canadian market for railbus services and identify potentially suitable railbus technologies worldwide. As previously mentioned, it was later decided not to undertake the detailed economics and routings study. Summary results presented herein can thus only be considered as preliminary information.

Avant d'entreprendre cette étude, le CDT a, en juillet 1985, confié au Canadian Institute of Guided Ground Transport (CIGGT) la tâche de faire une étude sur l'existence, au Canada, d'un marché pour les railbus et de déterminer les matériels qui conviendraient le mieux. Cependant, comme il a été mentionné plus tôt, cette étude a été annulée; donc, seules les informations sommaires suivantes peuvent être données.

Several European railbus designs were identified, as well as the UTDC/MCI concept, a Japanese railbus, and two European diesel-railcars similar to the Budd RDC but lighter in weight and lower in cost.

L'étude a considéré plusieurs railbus de fabrication européenne et un autre de fabrication japonaise ainsi que deux engins diesel européens semblables à l'autorail Budd mais plus légers et plus économiques et, bien sûr, le concept UTDC/MCI.

The market analysis showed three distinct areas for potential railbus applications: ultra-low demand

L'étude de marché a mis en évidence trois marchés distincts où l'utilisation d'un railbus serait justifiable :

remote services, regional networks, and feeders to trunk lines. The primary market (remote services) would require 12 to 15 single railbus units plus spares and baggage trailers. The regional market might require 50 to 60 units to replace conventional equipment now in service. It was estimated that railbus technology offers cost reduction potential of 30 to 40% compared to conventional rail services using locomotives and coaches. Crewing requirements are critical to the success of railbus operation. Some restrictions must be accepted for railbus operations. These include limited peak capacity (implies excess demand occasionally) and only basic amenities such as toilets, small galley, and reclining seats. If these restrictions are not acceptable, the railbus operations concept will be eroded severely with loss of potential cost savings.

Program Conclusions and Recommendations

The following conclusions and recommendations are based on the experience gained in the course of the work done to date and reports submitted by project contractors and consultants.

1. The service design and routings to be considered for railbus operations are essential to the evaluation of this vehicle technology and its associated economics, as well as to comparisons with alternative technologies. Service requirements should be carefully developed on the basis of passenger needs and considered in the formulation of vehicle specifications and selection criteria. It may not be as important to have a uniform vehicle fleet as it would be to have minimum costs and flexible service.

2. On some long distance services, such as Winnipeg to Churchill, railbuses cannot be viewed simply as a replacement of existing conventional technology. Service design, routings, and operating authority should be reviewed and tailored to local needs.

3. The detailed travel patterns between the various linked communities in remote services should be examined to optimize routings and minimize travel times. Multimodal links should be considered.

4. Reducing crew strength is absolutely critical to the economic success of a railbus operation. While two–person operation is

les régions isolées à densité de population faible, les réseaux régionaux et le rabattement sur les grandes lignes. Pour le premier de ces marchés (les régions isolées), il faudrait de 12 à 15 engins simples, sans oublier les pièces de rechange et les remorques à bagages. Pour le deuxième (réseaux régionaux), de 50 à 60 engins seraient nécessaires afin de remplacer les matériels actuellement en service. Les économies réalisables grâce au railbus ont été évaluées entre 30 et 40 p. 100 comparativement aux trains actuels. Le nombre du personnel de bord est un paramètre critique. Quelques contraintes doivent être acceptées à l'égard du railbus, notamment en ce qui concerne la capacité maximum, qui pourra à l'occasion être dépassée par la demande, et les aménagements pour le confort des voyageurs : toilettes, petite cuisine et sièges inclinables. Faute de quoi, l'économie visée avec la desserte par railbus risque d'être fondamentalement compromise.

Conclusions et recommandations

Les conclusions et recommandations qui suivent sont le fruit de l'expérience acquise tout au long des travaux ou sont tirées des comptes rendus faits par les contractants et les consultants.

1. Le niveau des services à offrir et les liaisons à desservir sont des paramètres essentiels dans l'étude technico–économique du railbus et dans le bilan comparatif avec d'autres techniques. Les niveaux de service doivent être soigneusement établis en fonction de la demande et pris en compte dans l'élaboration des critères de conception et de sélection. Il n'est pas aussi important d'avoir un parc formé d'engins d'une seule marque que de réaliser les coûts les plus bas et de disposer d'un parc offrant une grande souplesse d'exploitation.

2. Sur des longs parcours, comme celui entre Winnipeg et Churchill, on ne saurait procéder à un simple remplacement du matériel classique par un railbus. Les facteurs de niveaux de service, d'itinéraires et d'horaires ainsi que le choix de l'autorité exploitante doivent être adaptés aux besoins à satisfaire.

3. Les caractéristiques de la demande de déplacements entre les diverses collectivités desservies en région éloignée doivent être prises en compte dans l'établissement de la grille des horaires et des itinéraires, sans oublier les liaisons multimodales possibles.

4. La compression du personnel de bord est un facteur critique absolu. Alors qu'il serait impensable d'opter pour un personnel supérieur à

probably inevitable on remote lines, the second crew member must be a jack-of-all-trades, handling tickets, baggage, express freight, and serving refreshments. Such innovative crewing arrangements should not be precluded on the basis that they do not fit the national pattern. The key is to provide arrangements appropriate to remote services.

5. Train capacity is often not strictly controlled on conventional remote services. The railways tend to provide surplus capacity to accommodate a large group that may unexpectedly show up (a rare event). With the limited capacity of even a two-unit railbus, the local population should be educated as to the need to provide the railways with advance warning for group bookings.

6. While equipment maintenance costs should be much lower for railbus than for existing equipment, this will not necessarily be the case if design is inadequate or if the equipment is not suited to the service needs.

7. Prior to finalizing a decision on any production order of railbuses, a pre-production vehicle built to required specifications should be extensively tested and modified as necessary.

8. In the case of BREL railbus technology, a pre-production vehicle suited to Canadian conditions is not yet available. Significant modifications would be required to provide, for example, adequate interiors, winterization, ventilation and air conditioning, height of entry steps, and increased power-to-weight ratio.

9. The key data not available in the evaluation work done with the BREL 141, owing to the low mileage operated, relates to reliability, availability, and wear patterns. To properly assess these critically important characteristics, future testing work with the 141 would need to permit operating over 100,000 to 150,000 km.

10. For in-depth evaluation of passenger response and high mileage operation at an acceptable cost, the BREL vehicle should be operated in existing and appropriate rail passenger services, replacing conventional equipment.

11. In Canada, railbus vehicles have generally been considered for light density remote services use rather than for mainline rail

deux personnes, surtout pour la desserte des régions isolées, l'agent de bord devra, quant à lui, s'acquitter de plusieurs tâches : contrôler les billets, manipuler les bagages et les colis express, servir les passagers. Ce régime de dotation novateur ne devrait pas être empêché du seul fait qu'il ne correspond pas à ce qui se pratique à l'échelle nationale. La clé du problème est de s'adapter aux circonstances particulières de la desserte des régions isolées.

5. Sur les trains classiques, le nombre de sièges offerts est généralement supérieur à la demande, afin de pouvoir répondre à une demande supplémentaire inattendue, un groupe, par exemple, éventualité quand même plutôt rare. Ceci n'est pas possible dans le cas du railbus et de sa remorque. C'est pourquoi la clientèle devra être invitée à prévenir l'exploitant en cas de réservation collective.

6. Il est normal que l'entretien du railbus soit moins coûteux que celui des matériels existants, mais cela pourrait ne pas être le cas si l'engin était mal conçu ou s'il était mal adapté aux conditions de service.

7. Un prototype présérie du véhicule dont on envisage la commande en série devrait être soumis à des essais exhaustifs et modifié selon les besoins.

8. Il n'existe pas encore de prototype présérie du BREL 141 qui ait été "canadianisé". Pour ce faire, d'importantes modifications sont nécessaires : aménagements intérieurs plus adéquats, hivérisation, ventilation et climatisation, réduction de la hauteur de l'emmarchement et rapport puissance-poids plus élevé.

9. On ne dispose pas de données suffisantes sur les performances exactes du BREL 141 (fiabilité, disponibilité et taux d'usure), à cause de la trop courte période d'exploitation. Pour une évaluation plus précise de ces paramètres importants, les distances parcourues lors des essais à venir devront se situer entre 100 000 et 150 000 km.

10. Afin d'évaluer à fond la réaction des passagers et de soumettre le véhicule à des essais prolongés dans le temps sans que cela n'entraîne des coûts excessifs, le BREL 141 devrait être mis en service voyageurs sur une liaison actuellement desservie par un train classique.

11. Au Canada, le railbus est généralement envisagé pour la desserte des régions isolées à faible densité de population plutôt que pour un service

operations. The major safety consideration involves the lower end load capability of railbus vehicles relative to conventional rail technology. Although BREL's steel underframe is less of a concern in this area than the proposed UTDC/MCI concept vehicle, it must nonetheless be given further careful consideration, especially in the context of regional and corridor routes with their heavier rail and road traffic. This issue must be resolved in cooperation with the railways and regulatory authorities prior to the purchase of pre-production or fleet vehicles.

12. Not all of the currently specified regulatory equipment such as bells, handholds, running boards, etc. should necessarily apply to a railbus product. These matters should be addressed with the railways and regulatory agencies to arrive at a new set of regulations specifically addressing railbus vehicles.

13. It may not be advantageous to single out the railbus vehicle and discard other possibilities at this point. Other options are available, including that of modifying and updating existing railcar (RDC) technology.

grandes lignes. La principale préoccupation sur le plan de la sécurité concerne sa résistance plus faible aux efforts de traction, comparativement aux matériels classiques. Bien que le BREL, avec son châssis en acier, soit moins préoccupant à ce point de vue que le véhicule UTDC/MCI proposé, il reste que cette question devrait être approfondie dans le contexte d'un service régional ou de rabattement, caractérisé par un trafic ferroviaire et routier beaucoup plus lourd. Cette question devrait être élucidée de concert avec les sociétés ferroviaires et les autorités réglementaires, avant la commande de modèles présérie ou série.

12. Un railbus ne devrait pas être équipé de tous les accessoires qui sont couramment obligatoires : cloches, poignées, marchepieds, etc. Ces questions devraient être étudiées de concert avec les sociétés ferroviaires et les autorités réglementaires pour se mettre d'accord sur une réglementation particulière au railbus.

13. Il ne faudrait pas, pour le présent, se laisser obnubiler par le railbus au détriment des autres options qui existent, tels les autorails diesel, dont la modification et la modernisation sont toujours possibles.

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1. INTRODUCTION

This report presents the main activities and results of the Railbus Development and Demonstration Program undertaken by Transport Canada (TC) under an intra-departmental tasking agreement signed in May 1985 between Passenger Policy and Programs Branch, Ottawa, and the Transportation Development Centre (TDC), Montreal.

The program was intended to assess whether the railbus concept could offer an attractive and lower cost means of providing rail service in sparsely populated, remote communities as an alternative to existing, conventional, locomotive-hauled coaches. Railbus technology incorporates a road coach body, engine, and transmission into a simplified, two-axle rail vehicle. Mass-produced components of road vehicles are substituted for the traditionally high-cost, custom-made, rail vehicle subsystems.

The scope of the program was limited to remote services, but was otherwise wide ranging and encompassed an examination of railbus technology, operating rules, institut ,nal arrangements, types of service offered, and economic considerations. Passenger demons.ration operation was to be undertaken with domestically developed and offshore railbus technologies. It was hoped that this would lead to a new formula for remote rail services that would be more cost-effective than traditional methods.

During the course of the program, the introduction of new passenger rail legislation and VIA's growing interest in railbus technology for regional and corridor feeder as well as remote services curtailed the need for a wide ranging, multi-dimensional evaluation relating only to remote services. Thus, in July 1986 Transport Canada decided to terminate its work under the intra-departmental agreement and mandated VIA Rail to pursue further railbus initiatives. Development of a new Canadian railbus was put on hold at the completion of Phase 1 of the work. The detailed routings and economic study to be performed by TC was canceled.

The work actually undertaken by Transport Canada involved many technical and operational initiatives with various contractors. Results have been documented in numerous reports, many of which have been published as TC publications (see Chapter 8, References). It was felt, however, that there was a need to combine these in one document for easy reference and to highlight the main results. It was also considered that it would be useful to present observations, conclusions, and recommendations by the TDC project team.

This report provides a summary of each of the four program elements undertaken: WCSS railbus, BRE-Leyland 141 railbus, UTDC/MCI railbus, economics and routings study. Each of these chapters presents results, conclusions, and recommendations drawn from contractors' reports. A separate chapter presents some overall conclusions and recommendations offered by the TDC project team.

2. BACKGROUND

2.1 CTC Hearings

During CTC hearings regarding the continuance of rail passenger services in northern Manitoba held in 1981 at Thompson, the Manitoba government suggested that "...alternative means of providing as good if not better service ..." to that already in place be investigated. The railbus concept, adapting the highway coach to railway operation, was proposed as a potentially attractive alternative meriting further detailed investigation. Following a meeting in Winnipeg called by the Canadian Transport Commission, the Manitoba Department of Highways and Transportation prepared a draft proposal suggesting that a railbus demonstration project be undertaken by the federal government in northern Manitoba. Although considered initially for use in northern Manitoba, a railbus was considered to be potentially beneficial in many other areas of Canada.

A rail passenger working group was constituted in Winnipeg on July 21, 1982, with the CTC as the sponsoring and overall coordinating organization. This group furthered the railbus concept and progressed the associated work during its early stages.

2.2 ERDA Agreement

The Canada/Manitoba Subsidiary Agreement on Transportation Development was signed on April 13, 1984. It earmarked $550,000 for a one-year project to develop and test, during 1984-85, a prototype Canadian railbus vehicle suitable for light density remote rail passenger routes. Financial contributions were $500,000 from Canada and $50,000 from Manitoba.

2.3 Start of Work with WCSS Vehicle

TDC contracted with Winnipeg Coach Sales and Service (WCSS), in April 1984 to adapt a used highway coach for railway use. TDC issued the contract to speed railbus vehicle development and get the work started while other technical and operational issues were being resolved.

In September 1984 VIA Rail agreed to accept responsibility for implementing a railbus service. Subsequent to a meeting between VIA and CN Rail, CN voiced strong technical and operational concerns regarding a railbus service on their railway lines and stated that it would not act without a CTC order. A railbus demonstration plan and the approach to be used to introduce the proposed passenger service had not yet been developed. Financial difficulties on the part of WCSS seriously compromised the schedule for completion of the railbus vehicle. Little progress was achieved.

2.4 Comprehensive Program Development

In December 1984, a review of the railbus program was undertaken within Transport Canada to formulate and propose new initiatives to expedite developments. In January 1985 a comprehensive development program was planned by Transport Canada for discussion with Manitoba that included: completion of the work with the WCSS vehicle, development and testing of a new Canadian railbus, and evaluation and testing of foreign technology. The work was planned to be completed within 24 months at a forecast cost of $1.95 million.

This plan was formally proposed to the government of Manitoba at a meeting of the ERDA Management Committee. Subsequent to further discussions between Ottawa and Manitoba, it was decided that Phase 1 of the proposal (including only the WCSS vehicle) would continue to be managed and funded under the ERDA agreement. Phase 2 (including foreign technology and a new Canadian railbus) would not be included under the ERDA and would be funded by Transport

Canada and DSS. Phase 2 would be administered and implemented by Transport Canada in full consultation with the government of Manitoba.

2.5 DGRP/TDC Intra-Departmental Agreement

On May 14, 1985, an intra-departmental agreement was signed between the Rail Passenger Directorate (DGRP) of the Canadian Surface Transportation Administration and the Transportation Development Centre (TDC) which mandated TDC to undertake the detailed definition, implementation, project management of the Railbus Development and Demonstration Program, and evaluation of the potential costs and benefits resulting from the application of railbus technology in Canada.

3. WCSS RAILBUS

3.1 Summary of Work Performed and Results

3.1.1 Highway Coach Modifications by WCSS

A contract was signed between TDC and Winnipeg Coach Sales and Service Ltd. (WCSS) in April 1984 to adapt a used Flyer highway coach for railway use and incorporating a modified road suspension (3). Unlike conventional rail vehicles, the WCSS railbus had two axles supporting rail wheels that are not rigidly connected to each other. Modifications undertaken entailed installing railway wheels, stabilizing the front axle, and strengthening the front suspension to minimize sway.

Initial operating tests took place July 11–12, 1984, on the Greater Winnipeg Water District (GWWD) railway line. Push, pull and powered tests were conducted, including braking and operation on curves of up to 16 degrees and through crossings at various speeds. The bus was also operated for a distance of 50 km (31 miles) at speeds of up to 64 km/h (40 mph). The bus performed all tests satisfactorily and the initial test program was judged successful.

Additional equipment was then added including: hydraulically operated turntable, snow plow, power winch, auxiliary heater, and double-glazed windows. Further equipment operational tests were conducted in February 1985. A long distance endurance and ride quality test involving a return trip between Winnipeg and Shoal Lake was undertaken on February 15, during which the railbus was operated over a total distance of 312 km (194 miles). The undercarriage was subsequently modified to improve ride quality. A final series of operating tests on the GWWD line was conducted in April 1985.

3.1.2 Tracking Stability Assessment by DSL Dynamic Sciences Ltd.

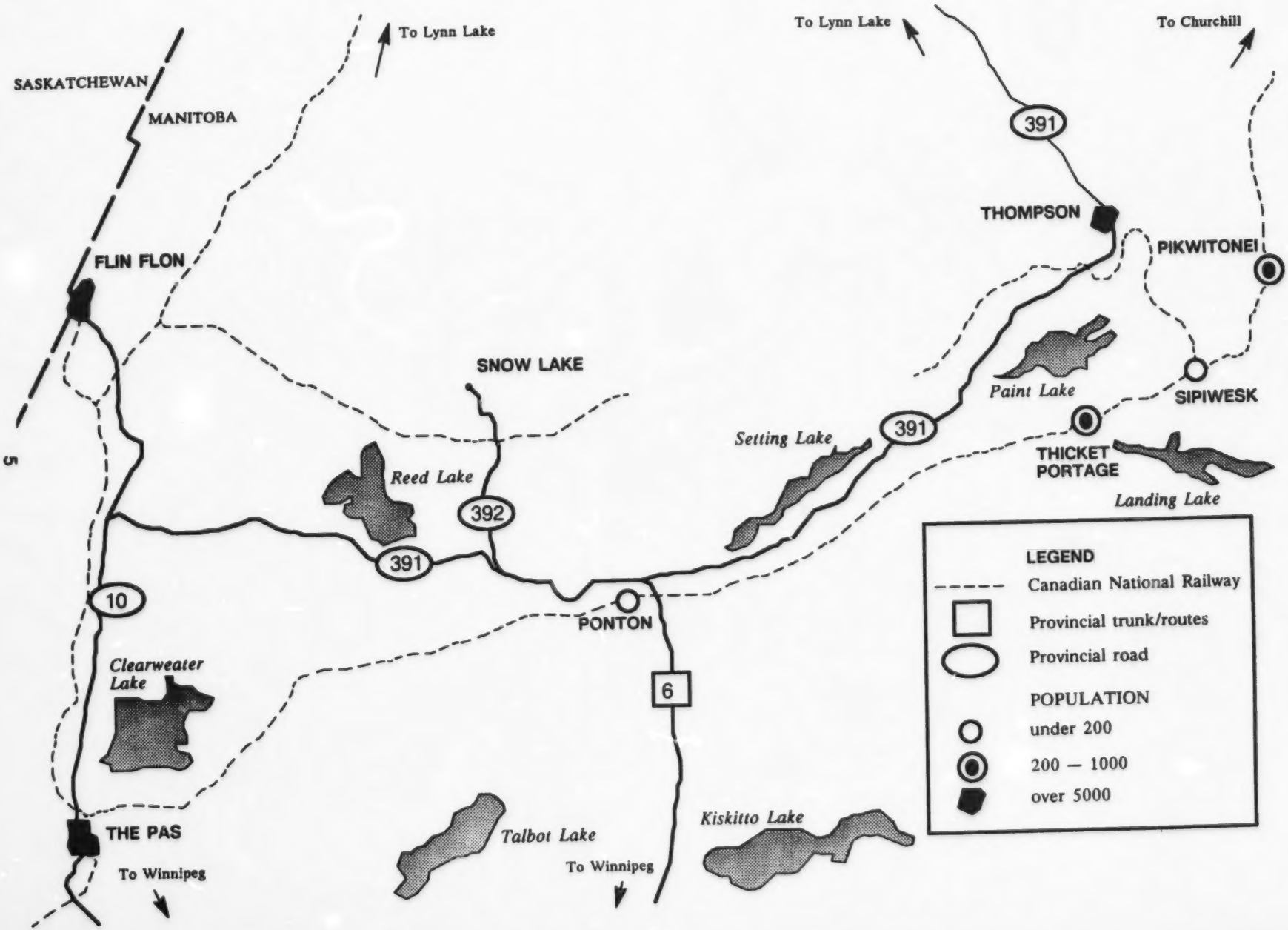
DSL Dynamic Sciences Ltd. (4) undertook an assessment of the tracking ability of this experimental railbus vehicle. This was based on a simple theoretical analysis of the vehicle dynamics and observation of the vehicle's ride during the long distance endurance tests undertaken in February 1985, during which speeds of up to 72 km/h (45 mph) were attained. On tangent track, lateral instabilities were observed beginning at about 56–64 km/h (35–40 mph) while on curved track these were present even at low speeds of 8–24 km/h (5–15 mph). No underdamped resonances corresponding to the natural body frequencies were noted. Possible mechanisms for the observed vehicle behaviour were presented, including the involvement of wheel condition and suspension characteristics. Recommendations were made for measurement of wheel/rail forces and for equipment modifications to improve ride quality.

3.1.3 Testing on Inco Line

In early July 1985, the WCSS vehicle was transported to Thompson, Manitoba, to undergo additional testing and modifications deemed essential prior to the start of any passenger demonstration service.

In September 1985, Transportation Technology Ltd. (TTL) under contract to TDC began intensive testing of the WCSS prototype railbus on the Inco Pipe Mine railway line in Thompson, Manitoba. This was in preparation for subsequent operation on CN Rail's Thompson–Pikwitonei–Thicket Portage line which had been selected for the passenger demonstration service (Figure 1). During the course of the tests, 3347 km of operation were accumulated. Tests carried out evaluated noise, lateral and vertical axle vibration, ride quality, wheel behaviour, stability, curving, switching, braking and operation of the various auxiliary systems including the turntable (6).

Figure 1
CN Rail's Thompson — Pikiwitonei — Thicket Portage line in northern Manitoba



The tests were generally successful and the vehicle was shown to be capable of sustained safe speeds of up to 90 km/h. Vehicle ride was judged to be "just satisfactory" on the British Rail Ridemeter scale. Wheel and bearing life was judged to be satisfactory for demonstration operation. Interior noise was a problem and was reduced from 93 dBA to 87 dBA by various modifications. The turntable failed after 50 cycles of operation and required strengthening and rework. During final vehicle inspection, it was discovered that the final drive unit was severely damaged and required repairs. The failure resulted from the manner in which the rear axle differential had been locked to provide the equivalent of a solid axle, by welding the differential gears. The welds appeared to have failed. Repairs were undertaken and the replacement unit was left in the unlocked condition. During subsequent retest, the unit proved satisfactory and vehicle performance was found to be unaffected.

CN's submission to the CTC in support of TDC's advance application of October 10, 1985, for non-passenger operation on the CN Thompson-Pikwitonei-Thicket Portage line was submitted on January 17, 1986. Relief was requested from the application of CTC requirements governing bell, sidesteps, ladders, running boards, and spark arresting system. CTC's authorization was issued on January 28, 1986, under Order No. R-38999.

3.1.4 Winter Operation on Inco Line

In December 1985, TTL began a further modification, testing and evaluation program that included winter operation on the Inco Pipe Mine railway in advance of non-passenger operation on the designated CN Rail line (7).

Modifications were undertaken to improve cold weather operations, including the installation of sanders and rail scrubbers, increased size of emergency heater fuel supply line, second bus battery as well as charging circuit, air drier, fuel/water separator, fuel heater, oil pan heater, coolant heater and circulator, battery trickle charger, temperature pressure compensated precision flow control circuit on turntable hydraulic system, skirts for protection of vehicle components, and insulation of driver floor area. In addition, turntable hydraulic fluid was replaced with N-Arctic (good for operation to -46 degrees Celsius), and fuel was drained and replaced with winter grade.

Operating trials were conducted on the Inco line during February and March 1986. During this time, 1593 km (990 miles) of operation were recorded and tests were conducted to evaluate: (a) design improvements for vehicle operation and reliability, and (b) vehicle performance in view of CN and CTC regulatory and technical requirements. Major equipment tests performed were as follows: turntable system, rerailing and winch operation, emergency heater, emergency engine shutoff, engine startability and reliability, snow removal and winter protection, reliability and wear, draw-bar operation, traction and braking, lighting, operation over railway crossings.

The various vehicle systems and equipment performed well overall and, where necessary for the subsequent passenger demonstration, rework was done. Inspection of wheel surfaces, bearing play, turntable and structural components indicated the equipment to be in satisfactory condition. The performance and reliability of the engine, drives and auxiliary controls were tested and found to be marginally acceptable for continued operation in severe winter conditions. The vehicle did not exhibit unusual wearing trends in its wheels, bearings or suspension elements during the winter test trials.

Snow removal using the pilot was tested at various speeds up to 60 km/h, with snow depths up to 250 mm. The design and operation of the pilot was found to be suitable. Vehicle engine power and traction ability with assistance from the wheel sanders was found to be adequate for demonstration service under winter conditions. The wheel sanders operated satisfactorily and were of considerable benefit in providing additional adhesion. As with most rail sanding equipment, special attention had to be paid to the quality and condition of the sand. Moisture could cause the sand to freeze inside the tanks as they were not fitted with localized heaters or vibrators to break and distribute the flow. An air activated "snow-brake" feature was added to prevent snow and ice build-up in the brake drum areas of the front and rear axles.

The vehicle was able to travel over level crossings that were snow and ice packed. Special attention was required to establish the depth and hardness of snow and ice accumulations over the rails in order to ensure that adequate flange guidance was available. Wheel sanders were often used to assist vehicle movement over level crossings. The main level crossing within Inco's maintenance yard facilities was used as the primary test site during the winter months. The tracks were not used by Inco's locomotives, therefore, snow and ice was well packed between the rails by heavy construction trucks which required the use of the crossing. The railbus, being considerably lighter in weight over the axles than conventional railcars, required a sufficient flange depth along the rail head to provide the necessary guidance. Level crossings in unknown condition were generally required to be checked and cleared with a hand shovel and track scraper before an attempt was made to move over such crossings.

On March 10, 1986, a general inspection and series of tests were performed by CN to verify that the railbus was ready for testing on CN track. The railbus was run at speeds of up to 64 km/h (40 mph) on poor track without exhibiting any instabilities. The overall ride quality was found to be improved substantially since the tests of February 1985 but still was considered marginal. The railbus was run through a 10 degree curve, forward at speeds of up to 24 km/h (15 mph) and backward at speeds of up to 16 km/h (10 mph). The "crabbing" motion exhibited in previous tests was not noticed. The turntable was tested and the improved hydraulic system and lengthened lifting platform provided smooth and stable operation. The deadman pedal was tested from a speed of 32 km/h (20 mph) and was found to be acceptable, stopping the railbus in 15 seconds, corresponding to a stopping distance of approximately 79 m (260 feet). The parking brake was applied from a speed of 30 km/h (20 mph) and the stopping time was measured at 12 seconds, corresponding to an average deceleration of 0.7315 (m/s)/s, 2.4 (ft/s)/s, and equivalent to holding the railbus on a 7.6% grade.

The headlights were tested and found to need improvement to make a person visible at a distance of 243 m (800 feet) rather than 183 m (600 feet) then recorded. The two-tone air horn was to be changed to a three-tone horn in order to meet CTC General Order O-25. Other minor modifications were identified involving: speedometer, flag holders, classification lights, marker lights, number box, and operator warning sign. The necessary further modifications were undertaken by TTL.

3.1.5 CN Operation and Passenger Demonstration

The CN crew were trained on the vehicle on April 29 and the first round-trip (without passengers) from Thompson to Thicket Portage, Pikwitonei and return was completed. Two weeks of non-passenger operation on the CN line were completed without incident during the period April 29-May 9, 1986. In total, eight complete round trips were made each requiring some 193 km (120 miles) and typically three or four turntable operations. Some minor difficulties were encountered involving a slipping alternator drive belt, and irritating noise levels at the driver's position. Noise levels did however meet CN standards for locomotives. The degree of controllability of both normal and emergency (deadman) braking and acceleration was extremely good by rail vehicle standards as foot-operated controls retained the bus feature of continuous variability. This enabled the driver to stop wheelspin or sliding very quickly.

Based on the results of these operational tests, several vehicle modifications were carried out. A three-tone CN locomotive horn was installed on the pilot. Two additional air reservoirs and a check valve were installed to safeguard the brake system pressure from depletion by the horn. A loud electronic beeper was installed to enable operators to signal their intention to move either forward or backward at stations. The alternator drive belts were changed to a smaller size to prevent slippage. These modifications were tested and found acceptable. No difficulties were encountered with the vehicle's turntable, brakes or driveline and CN operator acceptance was good.

An application to the CTC requesting authorization for a free-of-charge, passenger demonstration operation on the CN Thompson-Pikwitonei-Thicket Portage line was submitted by CN on May 23, 1986 and CTC approval was received June 9, 1986.

The service schedule for the passenger demonstration was developed with the assistance of the local communities and the government of Manitoba. This schedule, shown below, was designed to permit same-day return, with a six-hour stopover in Thompson. It was also intended to complement the VIA Rail schedule, providing service on Tuesdays, Thursdays, Saturdays when VIA trains were not available.

Operating Schedule
Railbus Passenger Demonstration
Thompson — Pikwitonei — Thicket Portage

TUESDAY (THOMPSON-THICKET PORTAGE)		THURSDAY (THOMPSON-PIKWITONEI)		SATURDAY (THOMPSON-THICKET PORTAGE-PIKWITONEI)	
DT	0800	DT	0800	DT	0800
ATP	0935	AP	0945	ATP	0935
DTP	0950	DP	1000	DTP	0950
AT	1125	AT	1145	AP	1100
				DP	1115
				AT	1300
		6 HOURS LAYOVER			
DT	1730	DT	1800	DT	1900
ATP	1905	AP	1945	ATP	2035
DTP	1920	DP	2000	DTP	2050
AT	2055	AT	2145	AP	2200
				DP	2215
				AT	2359

SYMBOLS; D — Departure A — Arrival
T — Thompson TP — Thicket Portage
P — Pikwitonei

Figure 2 shows passengers descending the WCSS railbus at the VIA station in Thompson. Inauguration of the passenger demonstration service took place on June 26, 1986. The initial week of passenger operation was successfully completed without incident. The limited seating capacity of the WCSS railbus (27 passengers) could not accommodate demand on the Saturday run.

For reasons relating to the availability of the British railbus in Canada, service between the communities was then provided with the BRE-Leyland 141 during the period July 1-August 23, 1986 (see Section 4.1.8).

The WCSS vehicle resumed passenger demonstration on August 26, 1986. On Saturday, August 30, at about 10 a.m., the left front wheel of the WCSS railbus failed about 3 miles outside of Thicket Portage. The TTL train rider noticed a change in noise and vibration levels and alerted the CN crew to bring the vehicle to a full stop in order to determine the source of the problem and whether it represented a safety concern for the crew and 14 passengers. Upon inspection, it was observed that the left front wheel had severe cracking around the mounting studs. Passengers were returned to Thicket Portage by All Terrain Vehicle while the railbus was stored at a siding. On Wednesday, September 3, the failed wheel was replaced with a spare and the vehicle was returned (without passengers) to the Inco shops in Thompson for detailed analysis and inspection by TTL personnel.

From stress analysis, inspection and testing of the wheels, TTL found that the wheel hub was overstressed, leading to a significantly reduced resistance to fatigue failure. In ideal circumstances, for the empty vehicle on a perfect track, the stress analysis revealed that the wheels were marginal in terms of fatigue strength. No allowance existed to account for real life conditions including: full passenger and baggage loads, vertical and lateral track inputs, method of torquing wheel nuts, material surface condition due to age, unknown material flaws, etc. The vehicle could not be operated safely with the current wheel design and would have to be withdrawn from service. The use of new rather than used wheels of the same design, as then on the vehicle, would not have changed this decision.

Figure 2
Passengers descending the WCSS railbus at the VIA station in Thompson

The minimum change solution to provide a sound suspension and wheelset for the railbus was found to involve more than just the design of a new wheel hub. Any new wheel hub design, whether based on a heavier standard road wheel or designed from scratch, would result in a stiffer hub and therefore a stiffer suspension. This would transmit higher dynamic loads to the bearings, axles, suspension components and possibly the bus body. All of these factors would have to be analyzed to determine the overall impact on the vehicle's integrity. TTL anticipated that a minimum change solution involving a new wheel would be technically feasible but may result in a limited life of axles, bearings, and suspension components.

It was estimated that the above work would take about 4–6 months to complete if there was full cooperation from INCO, CN and the CTC. Since it was not desirable to reinstate the passenger demonstration under full winter conditions, the earliest date for a restart was estimated to be about March/April 1987.

Based on the estimated costs of repairs and the associated timing, Transport Canada decided not to repair the vehicle and to terminate the WCSS demonstration.

3.2 Conclusions

1. The WCSS railbus, overall, was found to be suitable for a limited passenger demonstration in remote service operation.
2. It was demonstrated that reasonable vehicle performance (in terms of stability, curving, switching, braking, and traction) can be obtained with a simple conversion of a highway coach to rail operation.
3. The vehicle was unreliable as a result of its age and considerable prior operation as a highway coach.
4. After many modifications and rework, the turntable performed satisfactorily in tests conducted to –40 degrees Celsius. However, it remained a source of operating complexity and concern respecting its reliability.
5. The failure of the modified rail wheel (which incorporates a road wheel hub) after 8,800 km of operation demonstrated the relative harshness of the railway environment on vehicle wheels, suspension and undercarriage components. It was shown that suspensions designed for road vehicles are not suitable in a rail environment.
6. The need for long term vehicle operation and testing for satisfactory assessment of reliability and maintainability was clearly demonstrated.
7. Many features added to meet the requirements of CN Rail and the CTC improved the vehicle's serviceability, reliability, performance, and measured level of passenger and driver comfort.
8. The operating rules, practices, and procedures employed during the tests provided for a safe environment for the operation of the WCSS railbus on CN lines.
9. Not all of the current CTC specified regulatory equipment such as bells, handholds, running boards, etc. should apply to a railbus product.
10. For rerailing, winch operation, and turntable use, it was concluded that two persons were the minimum number required for safe operation.
11. Passenger acceptance of the vehicle was good; however, this could not be fully assessed owing to the short period of passenger operation undertaken.
12. Other than for high interior noise, crew acceptance of the vehicle was good. Vehicle operation was simple, and crew training could be accomplished in a matter of minutes.

3.3 Recommendations

1. The WCSS railbus wheels should be redesigned and the vehicle retested if further demonstration is to be carried out.
2. For general operation, railbus vehicles should be designed to permit double ended operation rather than incorporate a turntable for reversing direction.
3. Further development of a railbus specific category of vehicle regulatory requirements should be pursued which would take into account the differences between remote service railbus operations and conventional rail with locomotives and coaches.

4. BRE-LEYLAND 141 RAILBUS

4.1 Summary of Work Performed and Results

4.1.1 Background

The BRE–Leyland (BREL) railbus was identified by TDC as a foreign vehicle that had the greatest potential for application in Canada, and that had an attractive purchase price. Very early discussions with BREL indicated a potential vehicle delivery in May 1985. BREL modifications to the vehicle required for winter operation in Canada and completion of BREL/TDC negotiations delayed arrival of the vehicle.

The vehicle to be delivered by BREL was to be a demonstrator of the 141 variety. Though mechanically similar to the current production 142 model, the 141 series does not have the wider body and interior appointments of the 142. The technical evaluation to be conducted was thus solely intended to assess technical and operational performance and system reliability. Tests were intended to evaluate the overall acceptability of: vehicle ride and suspension performance, winter operations (e. g. traction ability on ice and snow covered track), signals shunting capability, performance and reliability of vehicle systems to cold weather and snow, maintenance requirements.

VIA, under contract to TDC, was to operate the vehicle and undertake acceptance and signals shunting tests, including making all necessary arrangements with CN and the CTC (9). TDC signed an agreement with the National Research Council (NRC) to undertake vehicle engineering tests as agreed with VIA (8).

4.1.2 BREL Modifications in England

TDC and British Rail Engineering Ltd. (BREL) signed a letter of understanding on January 23, 1986 to bring the BREL 141 demonstrator railbus to Canada. The BREL vehicle was shipped from England on January 25 and arrived at VIA's Montreal maintenance facilities from Halifax on February 8, 1986.

Prior to shipment to Canada, the vehicle underwent over 50 modifications resulting from the experience with European winter tests in Sweden and Norway, and expected requirements of the specific Canadian operating and climatic environment as provided by TDC, CN, and VIA. In advance of testing in Sweden, the vehicle had further undergone about an additional 50 modifications for winterization purposes.

4.1.3 Vehicle Modifications in Canada

Under contract to TDC, VIA carried out a number of modifications to satisfy CN and CTC requirements that were necessary to obtain authorization to operate the vehicle for test purposes. These included: sealed beam headlights, marker lights, flag holders, train number boards, bell, three tone air horn, radio, sill steps and grab irons, uncoupling levers, fire extinguisher, stretcher, first aid kit, and emergency tools. VIA personnel and a maintenance specialist supplied by BREL further verified and prepared all vehicle systems and maintenance points in advance of vehicle operation.

4.1.4 Acceptance Tests

Under contract to TDC, VIA undertook a number of yard acceptance tests that were necessary in order to qualify the vehicle for test operation on CN lines. These acceptance tests were

undertaken in VIA's Ville St-Pierre yard and maintenance facility and included: coupling to a CN locomotive, evaluation of curving and switching behaviour on yard tracks, braking operation checks, inspection of safety appliances, check for operation of all mechanical and electrical systems, measurement of wheel profiles, examination of pilot and general construction for potential derailment hazards.

4.1.5 Engineering Tests

The tests carried out by NRC involved engineering performance parameters such as wheel lift, vibration, curving performance, tracking stability, acceleration, braking, as well as passenger comfort criteria such as ride quality, lighting, temperature and noise. The vibration data permitted ride quality and tangent track stability analysis.

The static wheel lift tests were carried out in the Porte Sept shop in Montreal, while the road tests were conducted in the Lac St-Jean region, on CN Rail track.

Fully loaded tests were accomplished by placing concrete blocks weighing a total of nearly 1,800 kg (4,000 lb) on-board.

Acceleration and braking times were recorded on FM tape from an axle-mounted sensor. Braking distances were physically measured on the ground. Noise, tracking stability,and ride quality (to ISO standards) were measured simultaneously up to the maximum speed attainable with the vehicle 96-100 km/h (60-62 mph). Lateral and vertical rail force measurements were taken from strain gauges that had been applied to a four-degree curve, while the railbus passed through in its loaded condition. The instrumentation for vibration measurements consisted of a lateral accelerometer on each axle, a vertical accelerometer on each end of one axle, and a tri-axial accelerometer package over one axle on the car floor. Judiciously placed thermocouples surveyed the interior vehicle temperature during the course of the tests.

The criteria for static wheel lift tests is generally that, for 1 inch wheel lift, the change in wheel load for any other single wheel shall not exceed 10%. The greatest wheel unloading was 595 kg (1310 lb) or about 9% of the static load. A wheel equalization range of 2.0-2.5% was recorded.

Ride quality is presented in the format of the ISO Standard for reduced comfort boundaries. This standard compares the vibration spectra sensed by tri-axial accelerometers (as resolved into one third octave band frequency ranges) with time endurance limits for reduced comfort as prepared by physiologists. From the ISO reduced comfort boundary diagrams, the ISO values are as follow:

ISO REDUCED COMFORT BOUNDARY VALUES

ISO	SPEED		LOCATION	LOAD CONDITION	TERRAIN/
hours	km/h	mph	A/B/Centre	loaded/empty	TRACK COND.
4	74	46	B	loaded	hilly/jointed
1	74	46	A	loaded	hilly/jointed
8	74	46	Centre	loaded	hilly/jointed
4	80	50	B	empty	hilly/jointed
2.5	80	50	A	empty	hilly/jointed
8	80	50	Centre	empty	hilly/jointed
4	96	60	A	empty	flat/CWR

The B-end axle is driven while the A-end is undriven. CWR = continuous welded rail.

Hunting is defined as a limit cycle oscillation resulting from the wheel/rail interaction which causes the flange–way clearance to be exhausted in a steady, repeated fashion. When the limit cycle oscillation persists for 5 cycles or more at an acceleration level corresponding to a wheelset lateral amplitude of 10 mm (0.4 inches) or more, the vehicle is considered to be hunting. From a time history of accelerometers recorded during a run at 100 km/h (62 mph) the following observations were made:

1. frequencies above 2 Hz were quickly damped;
2. a vertical resonance at about 1.2 Hz was damped in 3.5 cycles after the disturbance;
3. a lateral resonance at about 1 Hz was damped in 2 cycles after the disturbance.

A spectrum analysis also showed minor peaks at 10.7 Hz and 12.4 Hz. The vehicle exhibited stable ride characteristics up to the maximum speed tested of 100 km/h (62 mph). No unstable modes of motion were detected during these tests. This is for the vehicle as tested, with new wheels.

A wheel lateral–to–vertical force ratio (normally denoted L/V ratio) of 0.8 is often quoted in analysis and test reports as a conservative criterion to evaluate the potential for flange climbing. The NRC tests were carried out on a 4 degree curve having a balance speed of 48 km/h (30 mph). Results for the 29–64 km/h (18–40 mph) speed range tested showed a single maximum L/V ratio of 0.44, with all others below 0.29. No erratic behaviour was noted during the curving tests.

During acceleration tests, the vehicle took 98.2 s to reach 72 km/h (45 mph) in a distance of 1306 m (4286 ft), in the empty condition. Loaded, it took 128.6 s to reach this speed in a distance of 1705 m (5594 ft).

In full service braking, the vehicle took 21.5 s and 112.1 m (368 ft) to brake from 77 km/h (48.3 mph), an average of 0.62 (m/s)/s, 2.03 (ft/s)/s. From 103 km/h (64.4 mph), the figures were 25.5 s and 198.1 m (650 ft), an average of 0.68 (m/s)/s, 2.23 (ft/s)/s. Emergency braking was not tested.

Interior light intensities were measured between 118 lx (11 fc) and 205.6 lx (19.1 fc) at lap height in the passenger seating area. In the aisle, intensities were 839.6 lx (78 fc) at eye level and 75.3 lx (7 fc) at floor level.

The temperature distribution was surveyed on a sunny day with the exterior temperature varying from –6 to –8 degrees Celsius. Temperature distribution inside the car was greatly affected by the sun. On the shady side, temperatures in the passenger compartments varied from 22 to 28 degrees Celsius at speeds of 48 and 80 km/h (30 and 50 mph). On the sunny side, in the direct sun, temperatures varied from 29 to 37 degrees Celsius at 48 km/h (30 mph) and 26 to 36 degrees Celsius at 80 km/h (50 mph). On the sunny side, lower down in the shade, temperatures were about 24 degrees Celsius.

Sound intensities were measured at 8 selected positions in the car at speeds of between 60 and 76 km/h (37 and 47 mph). Noise levels were in the range of 64 to 66 dBA with an increase of about 5 dBA near the side doors and a large increase of about 10 dBA in the passenger area when the auxiliary fans were on.

4.1.6 Signals Shunting and Other Operational Tests

Signals shunting tests were conducted by CN between mile 10.0 and mile 25.0, Alexandria Subdivision (10), and between Mile 35.5 and Mile 42.70, Rouses Point Subdivision. These territories were chosen to obtain a variety of in–service track circuits (DC, audio frequency overlay, DC coded, and motion detection) used for wayside signalling and highway/railway grade crossing systems, and because the rail surfaces provide excellent shunting conditions due to the weight and frequency of rail traffic. The testing performed indicates that the shunting capability of the railbus compares favourably with the shunting capability of a single unit rail diesel car (RDC).

The railbus was operated past two hot box detector sites, one using Servo model 7707 and the other model 8909 scanner units. It was found that the scanning path between the 7707 unit and

the wheel bearings is obstructed by the undercarriage arrangement of the railbus. With the newer 8909 system, equipment at the central reporting office is arranged to monitor movements with four or more axles only, to avoid annoyance readouts of hi-rail units, track motor cars, etc. Readouts of single unit railbuses are suppressed.

The overnight shore power system indicated inside temperatures ranging from 22-27 degrees Celsius at an outside ambient temperature between -12 to -10 degrees Celsius. Little other data is available as the shore power system was rarely used. The weather was not extremely cold and the vehicle was usually placed inside a heated shed overnight.

Fuel consumption was estimated at 51.5 L/100 km or 5.53 mi/g, based on 1832 km (1138 miles) covered in the Montreal area and an estimated 935 L of fuel added. Passengers were not being carried during this period and overall vehicle loading can be considered light.

4.1.7 Winter Operational Results

Because of late delivery of the vehicle to Canada, full winter testing could not be achieved. Operations in this regard were limited to several snowy days encountered in the Lac St-Jean region during which a minimum temperature of -21 degrees Centigrade was observed. On one occasion the vehicle drove through 304 to 508 mm (12 to 20 inches) of snow, with drifts estimated at 762 mm (30 inches), with no problems. The car was stopped and restarted in deep snow. The only difficulty was freezing-on of the brake blocks.

One component failure was experienced during 1832 km (1138 miles) operated in the Montreal area. This was the failure of one of the two alternators. Inspection showed that the ground leads on both alternators were loose. causing arcing which destroyed one control circuit board. While waiting for a new circuit board from England, the vehicle continued to run for several days, including the return journey to Montreal, on one alternator only.

The most important technical deficiencies noted by test team members during the period it operated in the Montreal area are considered to be the following: poor door seals, difficult entrance steps, uneven heating distribution, cold windows and side walls, low engine power, slow shifting transmission, inadequate compressor, inadequate alternators, brake shoe freeze-on in cold weather, and inaccessibility of various components and systems.

4.1.8 Passenger Demonstration on CN Line

Passenger demonstration operation was undertaken on the CN line between Thompson, Pikwitonei, and Thicket Portage for an eight-week period during July 1 to August 23, 1986, during which a total of 7564 km (4700 miles) were accumulated. As with the WCSS vehicle, the service schedule called for 2 round-trips to be operated from Thompson, with a 6-hour stopover in Thompson between each trip, on: Tuesday, to Thicket Portage; Thursday, to Pikwitonei; Saturday to both Thicket Portage and Pikwitonei. The vehicle carried an estimated 724 passengers in total on the Tuesday service to Thicket Portage. The Thursday service to Pikwitonei carried approximately 604 passengers. The Saturday service to both Thicket Portage and Pikwitonei carried 850 passengers, for a grand total of 2178 passengers.

Generally, the service was found to be attractive. The vehicle entry steps were the most significant area of negative public comment due to the vehicle's design for passenger entry from high level platforms as commonly found in Britain. Interior heating was excessive on clear sun-lit days due to the lack of air conditioning, sealed windows, and no direct shut-off for the auxiliary heaters. The operating crews liked the vehicle and found it easy to operate. Passengers preparing to board the vehicle are shown in Figure 3.

The VIA field officer conducted random verbal surveys of passengers. The service was found to be used for a variety of reasons including: medical appointments, employment access, access to banking facilities, shopping, acquisition of spare parts for all-terrain vehicles, visiting family and

friends, social and entertainment outings. The railbus carried passengers going to a wedding, sport instructors, education staff, local community and political representatives on their visits. Fishermen, construction workers, and tourists were also carried. In terms of reasons for travel, the results were skewed by the issuance of free tickets, the school holidays, and the number of children travelling for the pleasure of the journey. The results were disproportionately weighted towards children travelling, which would probably not be the case for a fare–paying service.

The vehicle operated reliably during the demonstration. On two occasions a temporary speed–shift problem arose. Over a slow order section of track, the unit had problems in the first and second notch ranges which led to power surges and a sudden protective shutdown of the engine. On another occasion, a problem arose with the shift but quickly cleared itself during the journey.

Average fuel consumption was estimated at 26–28 L/100 km (11–12 mi/g). The higher consumption recorded previously during the Montreal area tests (51.5 L/100 km) resulted from extended idling time and fuel used in the vehicle's heaters during winter operation.

Figure 3
Passengers boarding the BREL 141 railbus in northern Manitoba

4.2 Conclusions

1. The vehicle is torsionally very soft as shown by the wheel lift tests.
2. As received, with new wheels, the vehicle has stable ride characteristics up to the maximum speed tested of 100 km/h (62 mph).
3. The vehicle has acceptable curving performance over the 29–64 km/h (18–40 mph) speed range tested as shown by the wheel lateral to vertical force ratio measurements (normally denoted L/V).

4. Ride comfort is adequate for short and medium length journeys as shown by the ISO Standard for reduced comfort values.

5. The low acceleration figures reflect the low vehicle power–to–weight ratio.

6. Over the range tested, stopping distances were roughly equal to those produced by an emergency brake application on conventional equipment and considerably shorter than distances for a full service application.

7. From a "signals" viewpoint, the railbus as tested may be operated in track circuited territory at speeds up to the 96 km/h (60 mph) tested. On territories where rail traffic is infrequent and devoid of heavy freight, it must be anticipated that the railbus will have shunting difficulties similar to single unit RDC equipment.

8. Hot box detector scanner and readout characteristics do not permit proper readings of wheel bearing temperatures.

9. Because of the short winter operation and low total mileage accumulated (9,500 km), not enough data is available regarding winter performance, reliability and maintainability under Canadian conditions.

4.3 Recommendations

1. Vehicle performance should be evaluated under long term operation in full Canadian winter conditions.

2. Meaningful data on reliability and maintainability should be obtained by accumulating high mileage operating experience.

5. UTDC/MCI RAILBUS

5.1 Summary of Work Performed and Results

5.1.1 Background

UTDC Research & Development Ltd. submitted an unsolicited proposal to DSS on May 13, 1985, for the design, manufacture, and demonstration of a Canadian advanced design railbus. The proposal was accepted in principle for funding support by DSS at a meeting held in Ottawa on July 10, 1985. The effective commencement date of the contract ultimately signed with UTDC was January 2, 1986, with a completion date of March 31, 1987. The contract work was to be divided into four phases as follows: 1) preliminary design and specification, 2) detailed design and construction, 3) testing at the Kingston track, 4) testing on a private rail line.

On June 20, 1986, the Minister of Transport decided that this project would be put on hold pending the test and evaluation results of the BREL technology. If the results were to prove unsatisfactory, then other options, including the further development of the prototype UTDC/MCI railbus concept, could be considered. The work reported herein pertains only to phase 1 (Conceptual design) which was already completed up to the time of the suspension of work (11).

5.1.2 Phase 1, Preliminary Design and Specification

The work carried out in Phase I started with a background review of existing railbus technology, including operating experience with the Winnipeg Coach Sales and Service Ltd. (WCSS) modified Flyer bus. In order to develop an overall target specification for the vehicle, this review was combined with an analysis of the operating requirements for remote services as well as a review of the regulatory and railway technical requirements.

During the course of the Phase I preliminary design work, the performance of the vehicle was analyzed with respect to the performance targets. Engineering concepts for the modification hardware were developed, taking into account cost, weight, compatibility with the performance envelope constraints, and the desired functions. The hardware modifications to the base bus that were investigated include: rail suspension, including rail wheels and axles; driveline and propulsion; brakes; special equipment such as snow-plow, lights, horns; means of obtaining bi-directional operation. The results are as follows.

Track-based systems for turning the vehicle were found not to be sufficiently flexible. A vehicle-mounted turntable was technically feasible but not operationally desirable. Bi-directional operation could be achieved through the use of a second driver's position at the rear on the pre-production prototype vehicle, and a back-to-back married pair for production vehicles where additional capacity was required. The concept railbus is shown in Figure 4.

A simple suspension design would meet stability requirements but result in a degraded lateral ride with respect to current conventional equipment. The lateral ride would be roughly equivalent, and vertical ride would be superior, to the ride of the current WCSS prototype vehicle. A more sophisticated design with cross-bracing between the single axles would achieve acceptable stability with ride equivalent to conventional equipment in both axes.

The selected 229 kW (305 HP) Detroit Diesel Allison 6V92-TA engine combined with a 4-speed automatic transmission with lock-up in the top three gears would achieve the required maximum speed and climb a 3% grade at 80 km/h at full accessory load. Fuel consumption would be 22.6 L/100 km (12.5 mi/g) empty and 23.4 L/100 km (12.1 mi/g) fully loaded on typical northern remote services, with average speeds in the 50 to 70 km/h range.

Tread brakes and actuators are available off-the-shelf for this application and could be activated by the coach air system.

Vehicle weight empty would increase from the baseline 12,400 kg to 14,500 kg, and fully loaded weight from 16,600 kg to 19,000 kg. Weight distribution would be 42.5% on the front axle and 57.5% on the rear axle.

Wheel sanders could be fitted if proven to be required by operational testing. There is more than adequate space for such an installation.

UTDC estimated that production vehicles in small batches of up to 20 vehicles would cost approximately $360,000 for a single bi-directional unit, and $645,000 for a married pair with one being a freight unit.

Brake slide protection may not be required but could be fitted based on test results.

Figure 4
The UTDC/MCI concept railbus

5.2 Conclusions

1. The remote service requirements for a passenger vehicle could be met by a railbus based on the conversion and modification of the MCI 102A2 intercity highway coach. However, this vehicle would be generally limited to applications in remote area services.
2. The railbus vehicle based on the converted MCI 102A2 highway coach could meet all regulatory requirements existing for conventional rolling stock except those for buff load and conventional coupling.

3. Not all of the currently specified regulatory equipment such as bells, handholds, running boards, etc. should apply in their entirety to a railbus product in remote service. Some equipment standards should be waived or modified for this vehicle type and application.

4. The preferred method of obtaining bi–directional operation is through the use of a second driver's station at the rear of the single vehicle and a back–to–back married pair where more capacity is required.

5.3 Recommendations

1. Suspension design work should focus on a cross–braced solution to the stability/ride trade–off problem.

2. The pre–production prototype vehicle should be constructed with two driving positions.

3. Further consultations with the CTC and the railways should be conducted in relation to buff load requirements and specific equipment standards.

6. ECONOMICS AND ROUTINGS STUDY

6.1 Summary of Work Performed and Results

6.1.1 Background

A detailed economics and routings study was considered essential to identify passenger rail routes Canada-wide that are good candidates for conversion to railbus technology, and to establish the potential economics of implementing these railbus services. The elements of costs and benefits that are the key to the economic success of the railbus program were to be identified to permit TDC to monitor these throughout the course of the work to ensure that the program stayed economically on course. It was also considered that negotiations with operators, unions, and regulatory agencies that would be necessary to achieve overall success could be more easily brought to a satisfactory conclusion once the associated economics were identified. Information on service requirements and operating environments would also be obtained that would be useful for decisions on railbus configuration and equipment.

As an introductory step to undertaking a full, detailed, economics and routings study, TDC commissioned the Canadian Institute of Guided Ground Transport (CIGGT) in July 1985 to undertake a preliminary assessment of the Canadian market for railbus services and identification of potentially suitable railbus technologies worldwide (12).

The results summarized in the following section are from the work performed by CIGGT, and can only be considered as preliminary information.

6.1.2 Preliminary Results of Railbus Technology and Market Assessment

Several European railbus designs were identified as well as the UTDC/MCI concept, a Japanese railbus, and two European diesel-railcar designs which are closer to the familiar Budd RDC but which are lighter in weight and lower in cost. Evaluations were done from data supplied by the manufacturers. The assessments included the following categories: passenger comfort and amenities, capital and operating costs, safety, operational flexibility, interface to existing railway operations, performance.

From the point of view of vehicle structural integrity, specific hazards were identified that are liable to be encountered on remote rail lines: hitting large animals; private vehicles parked on the track or at grade crossings; freight cars parked on the railway track; frozen snow banks at freight crossings; collisions with road vehicles at grade crossings; derailment due to track defects.

The application of reduced capital cost vehicle technology to remote and regional passenger services was examined. The market analysis showed that Canadian applications for railbus-type equipment fall into three distinct categories:

1. remote services on very low utilization freight lines;
2. regional services to small communities on quasi-linear or branched routes; and
3. feeder services to corridor or trunk operations.

Within each application category, there are routes that are short (less than 4 hours) and those that are long (up to 16 hours). Demand varies from 20 to 150 seats per train. In the primary market, the remote services, it was estimated that there may be a requirement for 12-15 single railbus units (plus spares and baggage trailers) in Canada. The regional market was estimated to require 50-60 units to replace conventional equipment now in service. The required unit capacities in regional service were found to be generally higher than for those in remote service applications.

There are potentially two other types of railbus market that were identified. If the railbus can provide an effective low-cost means of transportation, there may be a demand for new, expanded,

or reinstated remote and regional services. This might also permit the development of remote and regional networks, which would improve equipment utilization. The second group of "other" markets involves the breaking–up of existing long trip regional/remote services into a series of individual, interconnected railbus routes. In addition, railbuses could be used to provide enhanced local and feeder services for transcontinental routes.

It was estimated that direct operating cost savings of up to 50% are possible using railbuses with appropriate crews. Capital cost could increase by two to three times, depending on the value assigned to conventional, existing equipment, and whether or not it would be refurbished for extended life. Total costs could be about 30–40% lower using a railbus technology.

6.2 Conclusions

1. Railbus technology offers significant operating cost reduction potential. Total costs, including capital, could be 30 to 40% lower than with conventional equipment using locomotives and coaches.
2. Crewing requirements are critical to the success of a railbus operation.
3. The equipment which satisfies the requirements of the remote service market only would not be adequate for the secondary regional market.
4. Some restrictions must be accepted for railbus operations. These include limited peak capacity (implies excess demand occasionally) and only basic amenities such as toilets, small galley and reclining seats. If these restrictions are not acceptable, then the railbus operations concept will be eroded severely with resultant loss of potential operating cost savings.
5. Railbus designs vary widely. Railbus technology must be shown to be capable of protecting its occupants from end, or side, collisions with any of the specific hazards liable to be encountered on rail lines. In the event of a rollover caused by derailment, the structure should retain its integrity and fire hazards should be controlled.

6.3 Recommendations

1. Railbus equipment should be procured for testing in the primary, remote service applications.
2. A minimum of one year of extensive testing is recommended to permit observation of railbus vehicle performance and reliability in all conditions and over an adequate accumulated mileage.
3. Key evaluation factors to be monitored should be: cold weather operation; maintainability at remote locations; operating costs; passenger amenities, effectiveness and utilization; baggage and freight handling; vehicle dynamics on poor quality track; vehicle operation in mixed traffic on main lines.
4. A comprehensive safety analysis of railbus technology and operations should be conducted.

7. PROGRAM CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are based on the experience gained in the course of the work done to date and reports submitted by project contractors and consultants.

1. The service design and routings to be considered for railbus operations are essential to the evaluation of this vehicle technology and its associated economics, as well as to comparisons with alternative technologies. Service requirements should be carefully developed on the basis of passenger needs and considered in the formulation of vehicle specifications and selection criteria. It may not be as important to have a uniform vehicle fleet as it would be to have minimum costs and flexible service.

2. On some long distance services, such as Winnipeg to Churchill, railbuses cannot be viewed simply as a replacement of existing conventional technology. Service design, routings, and operating authority should be reviewed and tailored to local needs.

3. The detailed travel patterns between the various linked communities in remote services should be examined to optimize routings and minimize travel times. Multimodal links should be considered.

4. Reducing crew strength is absolutely critical to the economic success of a railbus operation. While two-person operation is probably inevitable on remote lines, the second crew member must be a jack-of-all-trades, handling tickets, baggage, express freight, and serving refreshments. Such innovative crewing arrangements should not be precluded on the basis that they do not fit the national pattern. The key is to provide arrangements appropriate to remote services.

5. Train capacity is often not strictly controlled now on conventional remote services. The railways tend to provide surplus capacity to accommodate a large group that may unexpectedly show up (a rare event). With the limited capacity of even a two-unit railbus, the local population should be educated as to the need to provide the railways with advance warning for group bookings.

6. While equipment maintenance costs should be much lower for railbus than for existing equipment, this will not necessarily be the case if design is inadequate or if the equipment is not suited to the service needs.

7. Prior to finalizing a decision on any production order of railbuses, a pre-production vehicle built to required specifications should be extensively tested and modified as necessary.

8. In the case of BREL railbus technology, a pre-production vehicle suited to Canadian conditions is not yet available. Significant modifications would be required to provide, for example, adequate interiors, winterization, ventilation and air conditioning, height of entry steps, and increased power-to-weight ratio.

9. The key data not available in the evaluation work done with the BREL 141, owing to the low mileage operated, relates to reliability, availability, and wear patterns. To properly assess these critically important characteristics, future testing work with the 141 would need to permit operating over 100,000 to 150,000 km.

10. For in-depth evaluation of passenger response and high mileage operation at an acceptable cost, the BREL vehicle should be operated in existing and appropriate rail passenger services, replacing conventional equipment.

11. In Canada, railbus vehicles have generally been considered for light density remote services use rather than for mainline rail operations. The major safety consideration involves the lower end load capability of railbus vehicles relative to conventional rail technology. Although the BREL's steel underframe is less of a concern in this area than the proposed UTDC/MCI concept vehicle, it must nonetheless be given further careful consideration, especially in the context of regional and corridor routes with their heavier rail and road traffic. This issue must be resolved in cooperation with the railways and regulatory authorities prior to the purchase of pre-production or fleet vehicles.

12. Not all of the currently specified regulatory equipment such as bells, handholds, running boards, etc. should necessarily apply to a railbus product. These matters should be addressed with the railways and regulatory agencies to arrive at a new set of regulations specifically addressing railbus vehicles.

13. It may not be advantageous to single out the railbus vehicle at this point. Other options are available, including that of modifying and updating existing railcar (RDC) technology.

8. REFERENCES

The following references provided are those directly related to the project work.

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